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A characteristic feature of any liquid fuel is the heterogeneity of its composition. This heterogeneity is enhanced by the presence of water in emulsified liquid fuels. It affects not only such characteristics of

the emulsified fuel as the heat of combustion, Q_H^p, theoretical tempera-

ture of combustion, t_T, viscosity, specific gravity, etc., but also the

combustion process of this fuel.

Until recently, it was believed that presence of water in fuel was a negative factor; attempts were therefore made to remove it from the fuel (especially from liquid fuel) by any possible means.

It is well known that the combustion of carbon monoxide in dry air takes place very slowly, whereas it is accelerated considerably in the presence of water vapor. There are also other instances of positive influence of the water medium (in the vapor phase); e.g., evaporation is faster in a humid than in a dry medium.

This has been confirmed by the experiments of V. A. Fedoseyev and D. I. Polishchuk (Ref. 1), who studied the evaporation of benzene droplets. They proved experimentally that the evaporation rate in dry air is lower than in the presence of water vapor.

Taking this fact into account, the authors drew the conclusion that it might be suitable to inject water into the cylinders of internal combustion engines, in order to accelerate the evaporation of the fuel charge and thus increase the speed and extent of its combustion.

The research work on the combustion process of various water-fuel systems, conducted in the laboratory for the physical chemistry of fuel combustion of the Institute for Mineral Fuels, Academy of Sciences, U.S.S.R., has proved the value of using water containing heavy liquid fuels in the form of emulsions in industry and power engineering and in transportation.

A well-emulsified mixture of liquid fuel and water constitutes a system in which the distribution of microscopically small water droplets in the fuel is fairly uniform. Such a system is very stable and is seldom disturbed over a long period, even one of several months' duration,

(as shown in Ref. 1). Photomicrographs (enlarged 600X) of pure mazut and a water-mazut emulsion of type W-M, (Figure 1), show that microscopic water droplets of 50-10 μ are uniformly distributed in the water-mazut emulsion.
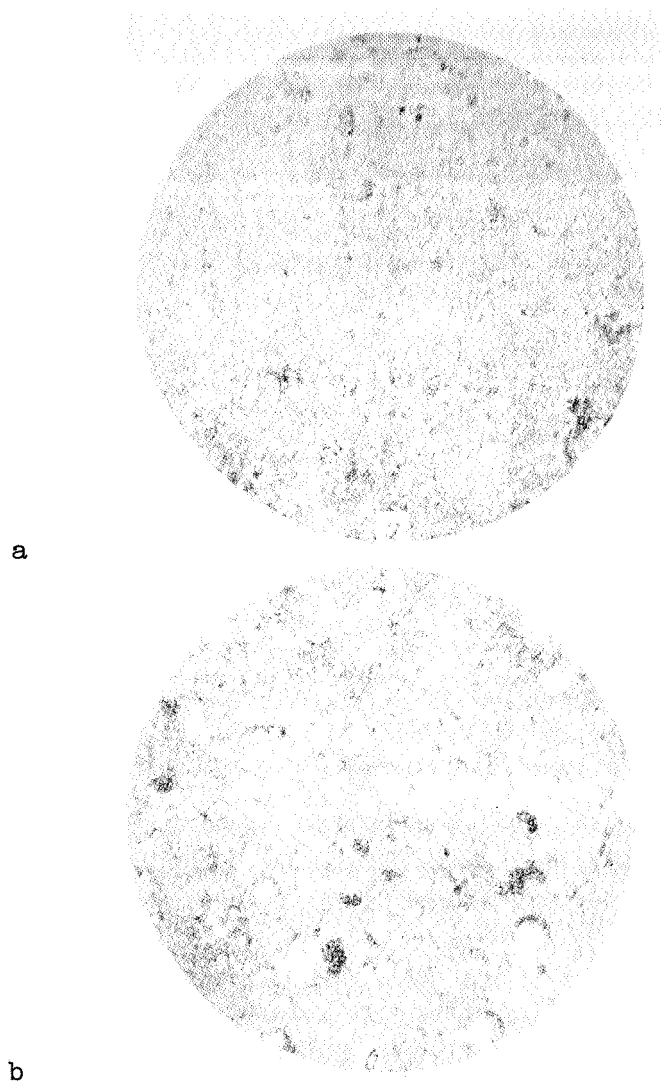

a

b

Figure 1. Photomicrographs

a - Pure mazut; b - Water emulsion of mazut

In addition to the study of the properties of the water-fuel emulsion and of the process of its combustion in a flow, an investigation using high-speed cenematography (200-300 frames per sec) was made into the mechanism of ignition and combustion of a single particle of emulsified fuel. Observations were made of a particle (droplet) of liquid fuel which had been introduced into a medium heated to a certain temperature. The experiments were carried out in an experimental apparatus (Figure 2), the basic component of which was a chamber in which the droplet was placed and surrounded by air of various compositions.

The capacity of the chamber was 250 cm^3. Three windows permitted inspection in reflected and transmitted light. The experiment was conducted in the following sequence: The chamber was heated to a certain temperature. A fuel particle in the shape of a round drop 0.8-3 mm in diameter was introduced with a quartz inserter into the chamber through a cooled channel. The particle was placed at a point within the field of vision of the objective of the motion picture camera, which was turned on before the particle reached the point on which the objective was focused. This permitted a determination of all the changes undergone by the fuel particle after its penetration into the heated air from the very start of its transformations. At the end of the combustion process, the combustion products were evacuated from the chamber by means of a water-jet pump.
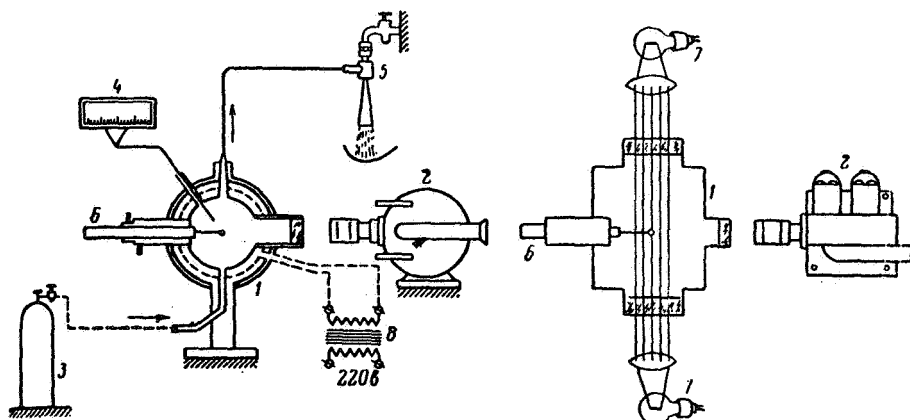

Figure 2. Schematic drawing of the experimental setup

1 - Chamber (heated); 2 - Motion picture camera; 3 - Gas cylinder;
4 - Millivoltmeter; 5 - Water-jet pump; 6 - Support for droplet;
7 - Illuminators; 8 - Current source

The filming made it possible to obtain an interesting qualitative picture of the ignition and combustion processes of a single particle of water-mazut emulsion and to clarify the characteristics of this process in comparison with that of anhydrous mazut particles.

It is known that when a fuel particle is inserted into a high-temperature zone it will undergo a series of physicochemical changes. The following was established in the course of the investigation: the pure mazut particle, introduced into the heated zone of air, began, after a certain period of warming, to evaporate from the surface. The vapors of the lightest fractions of hydrocarbons, having reached a sufficient concentration above the surface of the particle, ignited. From this moment on the process of fuel combustion started around the vapor phase of the particle. In the relatively immobile medium, a typical diffusion process of droplet combustion took place.

The motion picture film of the ignition and combustion process of the pure anhydrous mazut particle (Figure 3) provides a graphic representation of the course of the process. The time interval between the frames is 0.0025 sec. The upper part of the photograph shows enlargements of the second and third frames of the film.

Let us examine the beginning of the process. The focus of ignition formed around the droplet (see the second frame from the right) is characteristic of the ignition of a gaseous mixture (in this case, a mixture of air and hydrocarbon vapors formed around the particle). The ignited hydrocarbon vapors promoted a more vigorous vaporization and combustion of particles.

Of a somewhat different character are the changes of a particle of the water-mazut emulsion during ignition and combustion. Figure 4 shows a filming of the ignition and combustion process of a particle of a water-mazut emulsion with a 30 percent water content. The time interval between frames is 0.003 sec. The top of the photograph shows enlargements of the third and fourth frames of the film.

It is apparent from the film that the course of ignition of the emulsion particle is quite different from that of pure mazut. The bright local focuses of combustion, visible on the sides of the particle in the third and fourth frames, show the ignition of the mixture of hydrocarbon vapors and air taking place around a number of smaller particles, which have been split off from the original droplet. The recorded time shows that, the temperature conditions being the same, the ignition of the vapors from the emulsion particle of water-containing mazut takes place earlier than that of the particle of pure dehydrated mazut.
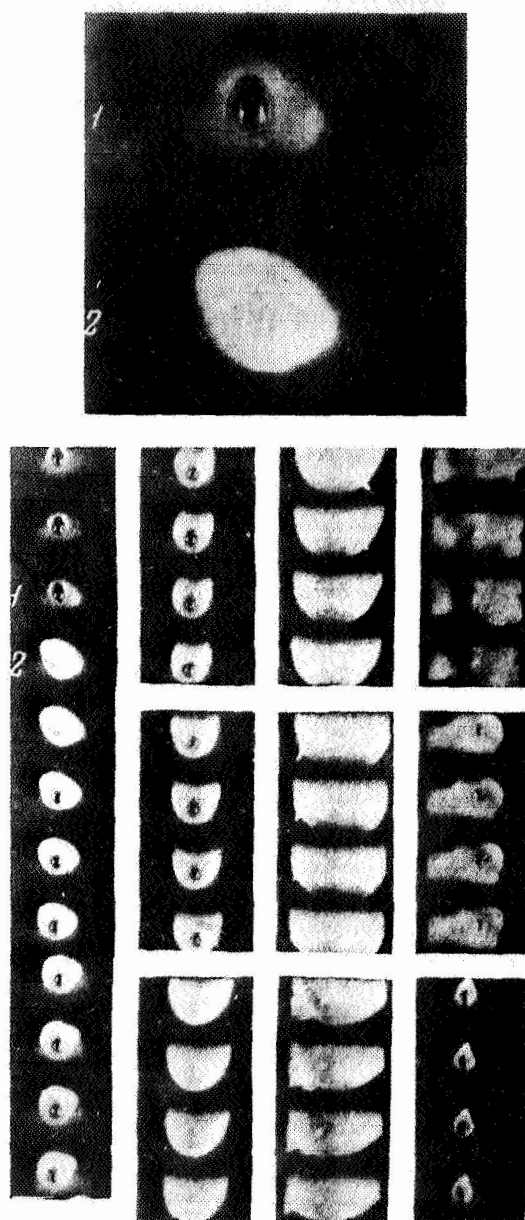
Figure 3. Motion picture film of the ignition and combustion process
of a pure mazut particle. Time interval between frames: 0.0025 sec.
Figures 1 and 2 indicate the start of ignition. Enlargements of
frames 1 and 2 are shown at top. (Sequence of frames: from top left
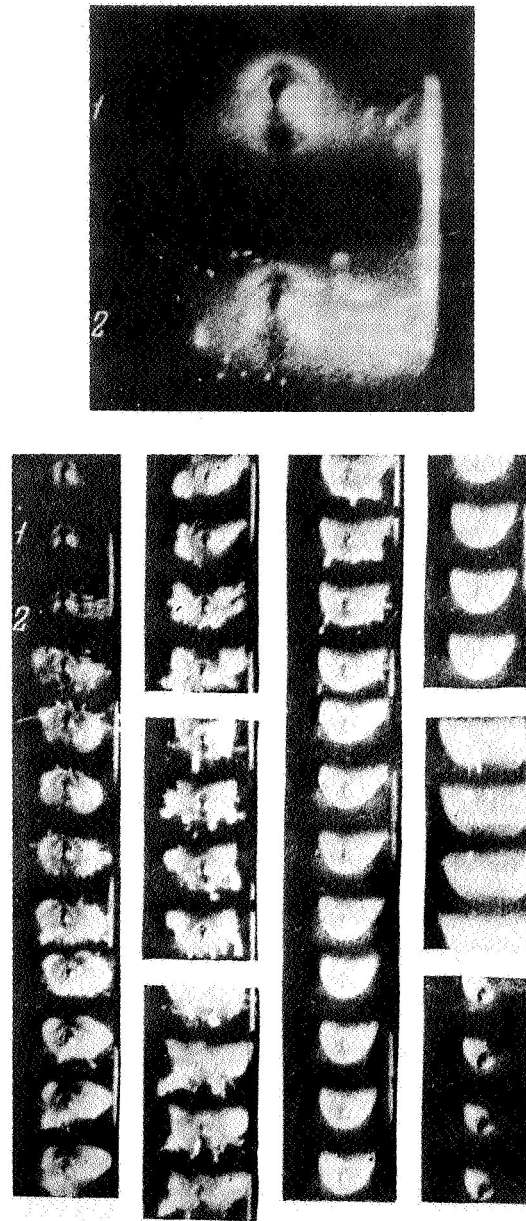down). End of quartz support is visible in the last frames.

Figure 4. Motion picture film of the ignition and combustion process of a particle 30 percent water-mazut emulsion. Time interval between frames: 0.003 sec. Figures 1 and 2 indicate the start of ignition. Enlargements of frames 1 and 2 are shown at top. (Sequence of frames: from top left down). End of quartz support is visible in the last frames.

Moreover, as seen from the film, the combustion process of the
emulsion is accompanied by bursts on the surface of the particles and
by the ejection of vapors. The emulsion particle burns out faster than
a particle of pure mazut of the same size, because of the breakup of
the droplet effected by these "microexplosions", as stated in Ref. 1.
It has been established experimentally that the mazut emulsion particles
start boiling some time before ignition. In order to determine the time
at which the particles of mazut emulsion and pure mazut begin to boil,
observations were undertaken in a neutral medium (nitrogen) in the tem-
perature range between 300° and 800°C.

These observations also showed that in a heated medium the emulsi-
fied mazut particle begins to boil earlier and at a lower temperature.

Figure 5 shows a diagram of the beginning of the boiling of parti-
cles of emulsified and pure mazut in a neutral medium between 300° and
800°C. One characteristic of the mazut emulsion particle was clearly
observed: the presence of two stages of boiling. The first stage con-
sists of the boiling and bursts produced by the water of the particle,
owing to the different boiling points of water and mazut. The heated
water present in the emulsified particle starts boiling and evaporating
earlier than the mazut. The water vapor ruptures the superficial film
with violence and breaks up the combustible substance of the droplet.
After evaporation of all the water from the particle, only the dehy-
drated mazut remains, which continues to heat, up to its boiling point,
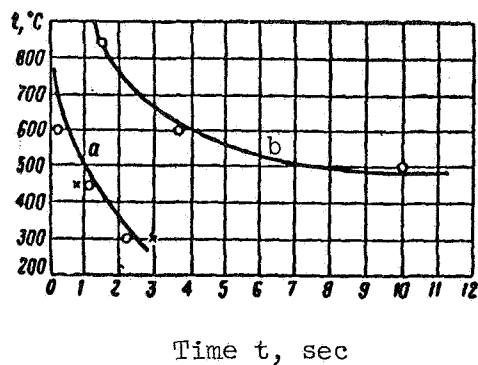

Time t, sec

Figure 5. Diagram showing the start of boiling vs
the temperature of the medium for a droplet of, a)
mazut emulsion, b) pure mazut. (Diameter of the
droplet: 2 mm. The neutral medium is nitrogen.)

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and the particle boils for the second time. The same sequence was observed in the combustion process of the emulsion (Figure 5). It is apparent from Figure 4 that the steam bursts the surface film. The droplet is thus broken up into smaller fuel particles, gaining more speed in relation to the heated medium and evaporating and igniting faster, bringing about an intensification of the combustion process. During combustion of the mazut emulsion particle, its breakup continues, until all of the water has evaporated. This phenomenon, which we have observed earlier, was called a "microexplosion". The combustion of the mazut emulsion particle is schematically presented in Figure 6.

Thus, the microscopic water particles present in the emulsified mazut cause an additional breaking up of its droplets into smaller particles and thus promote a better mixing with the oxidant and a more complete combustion.

This important feature not only accelerates the combustion process of the fuel, but also permits the reduction of the excess air
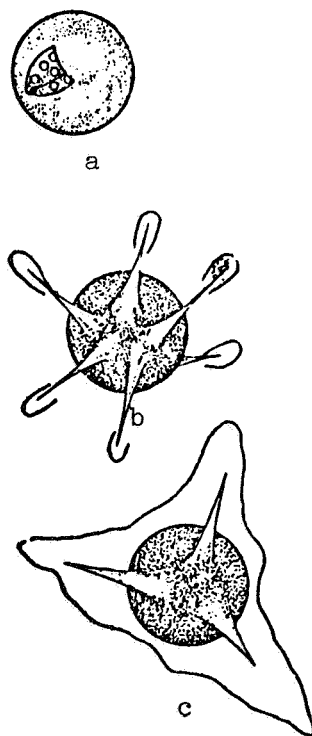

Figure 6. Schematic drawing of the ignition and combustion of a particle of water mazut emulsion, a) microscopic water droplets in mazut envelope; b) injections of mazut particles; c) evaporation and combustion during breakup of emulsion

coefficient to a minimum value ($\alpha = 1.05 - 1.07$), the extent of combustion being the same. This mechanism which we have observed in the behavior and combustion of emulsified, water-containing liquid fuel, also takes place in actual furnace units.

This explains the intensification of the combustion process observed when emulsified water-containing liquid fuels are used in furnaces, engines, stoves and other thermal units.

The catalytic influence of water vapor may also be manifested in the final stage of combustion of heavy liquid fuels and in the final burning off of carbonaceous residue. Observations of the ignition and combustion of an emulsified droplet of kerosene, a fuel lighter than mazut, has shown that the process involves the same two stages and that the combustion takes place with the same microexplosions which were seen in the combustion of the mazut emulsion droplet.

Study of the mechanism of the process has shown that water in liquid hydrocarbon fuel, even in amounts of 50 percent by weight, when its microscopic particles are uniformly distributed in the fuel, i.e., emulsified, not only does not hinder the ignition and combustion, but, on the contrary, improves the conditions of these processes through additional breakup of the droplets by the microexplosions described. Further observations made by filming the behavior of droplets of natural and emulsified fuel in heated media involved the simultaneous measurement of temperature versus time at predetermined points.

During the combustion of the droplets, the temperature was measured both inside the droplet and at some distance from its surface in the zone of burning of the fuel vapors surrounding the droplet (in the latter case, with a differential thermocouple). The thermocouple or a special quartz filament served as the support for the droplet.

Typical oscillograms of the temperature recorded inside a droplet of mazut, mazut emulsion, kerosene emulsion, and emulsion of gaseous benzine, obtained by experiments of this kind, are shown in Figure 7. The examination of the combustion process of the fuel droplets was conducted at an air temperature of $500°-860°C$ in a medium of low mobility with simultaneous radiation of the chamber walls. The fuels used were: kerosene, mazut (of M-40 and M-60), and also emulsions of gaseous benzine, kerosene and mazut, containing 20-40 percent water.

Droplets 0.8-3.0 mm in diameter were used in the experiments; the diameter was determined with a microscope provided with an ocular micrometer. A detailed study of single droplets during the combustion process confirmed the above-indicated essential difference in the combustion processes of anhydrous and emulsified water-containing fuel, and clarified some qualitative characteristics of this difference. In
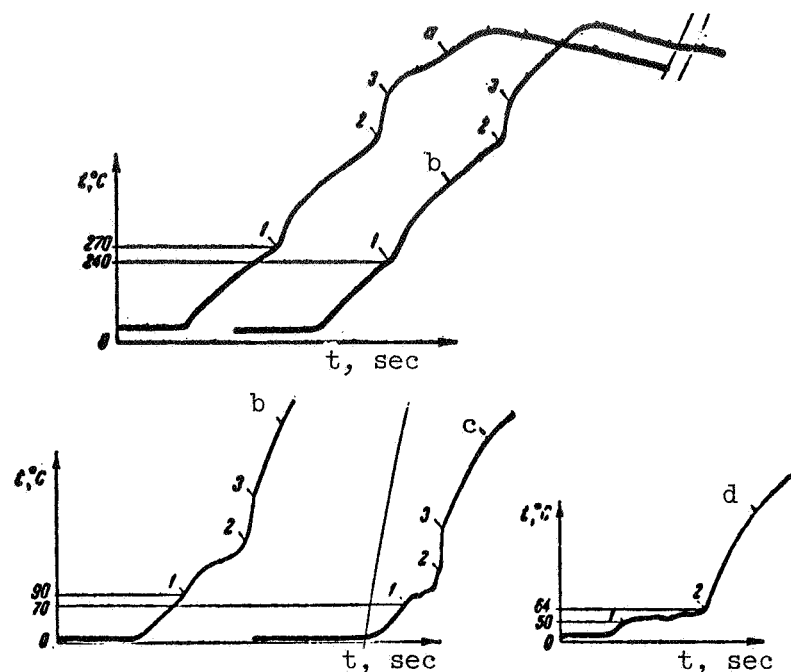
Figure 7. Typical oscillogram recording the temperature
inside the droplet during ignition and combustion. (The
temperature is determined by thermocouple, on which drop-
let has been suspended.) a) mazut, b) 30 percent water-
mazut emulsion, c) kerosene, d) 20 percent water-kerosene
emulsion, e) emulsion of gaseous benzine. Characteristic
points, 1. moment of ignition, 2. moment of disappearance
of the liquid phase, 3. end of the combustion of the hy-
drocarbons

addition, these experiments provided a clear picture of the combustion
of heavy liquid fuels with or without water, and also permitted the es-
tablishment of the difference in the combustion of heavy (mazut), medium
(kerosene) and light (gaseous benzine) fuels. These experiments con-
firmed that the combustion process of heavy liquid fuels consists of the
following basic stages: heating and vaporization of the particles, ig-
nition and combustion of the fuel vapor with simultaneous pyrolysis
(thermal dissociation) of the heavy hydrocarbons in the vapor phase, de-
position of free carbon, and finally, heating and burning of the carbo-
naceous residue (soot).

Combustion of the water-emulsified fuel takes place in the same
sequence, except that microexplosions of the particles precede the ig-
nition of the fumes of heavy fuel; the combustion of the emulsion of the

middle fuel is more vigorous and quicker than the combustion of the same fuels not emulsified with water.

As an example, we offer comparative data on the combustion time of drops of anhydrous and emulsified fuels (Table 1).

Similar results have been obtained with the combustion of droplets of other dimensions. Temperature measurements of the liquid phase during the combustion of mazut and emulsion drops (with a water content of 20-30 percent) of equal dimensions and under the same conditions showed that the temperature of the drops during the evaporation and combustion rises continuously. This is apparent from the typical oscillograms (Figure 7).

The rise in the temperature of the liquid phase in the course of vaporization and combustion of the drops indicates a successive fractional vaporization first of the light, then of the heavier hydrocarbons which have correspondingly higher vaporization temperatures. Measurement of the temperature of the liquid phase of the drops combined with motion pictures, made it possible to follow the various phases of the process, to determine their duration, and to identify certain quantitative characteristics which distinguish the combustion of the emulsion from that of anhydrous fuels.

It was noted that the heating period preceding ignition was shortened for emulsified fuels; moreover, the temperature of the liquid phase of mazut emulsion droplets at the moment of ignition was somewhat lower ($t_{BE} = 240^{\circ}$) than that of mazut droplets ($t_{BM} = 260^{\circ}-270^{\circ}$). The size of the droplets has a substantial influence on the duration of the heating, i.e., on the period from the beginning of the insertion into the heated medium until the moment of ignition.

Generalized data characterizing the effect of the diameter of the drops on their heating time at a constant temperature of the medium ($t_{med} = 270^{\circ}$), are shown on a graph (Figure 8), and the effect of the temperature of the medium on the duration of this heating stage for a constant size of the drops is shown in Figure 9.

An appreciable difference is observed by comparing the temperature oscillograms of the liquid phase of a droplet of an emulsion of gaseous benzine (during the combustion of the vapors) with the temperature oscillogram of the liquid phase of a droplet of a burning kerosene emulsion (see Figure 7). This difference consists of the fact that in the combustion of a light fuel such as gaseous benzine, the duration of the heating stage, as well as the temperature of the liquid phase corresponding to the moment of ignition, decreases. In addition, during the combustion of a droplet of pure or emulsified kerosene, the temperature of

Table 1

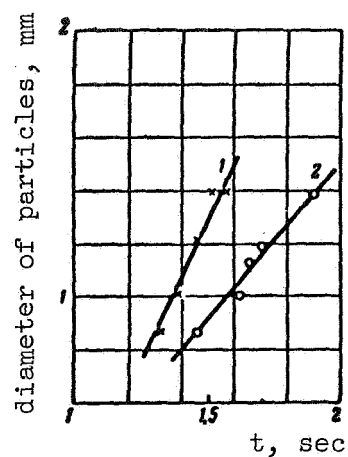| Fuel	Diameter of the droplet mm	Temperature of the medium °C	Combustion time of droplet sec	Relative combustion time of emulsion droplet percent	Remarks
Mazut emulsion M-60, 30 percent water content........	2.8	800	2.8	0.75	Without including the burning time of the carbonaceous residue
Mazut M-60.....	2.8	800	3.74	—	
Mazut emulsion M-60, 30 percent water content........	1.1	710	2.68	0.8	Including burning time of the carbonaceous residue. Droplets were suspended on a quartz filament
Mazut M-60.....	1.1	710	3.3	—	
Kerosene emulsion, 30 percent water content........	1.2	760	0.92	0.58	
Pure kerosene.	1.2	760	1.59	—	

Figure 8. Influence of particle diameter on the time of heating at a temperature of the medium of 720°C. (heating period is the time interval from the insertion into the heated medium up to the moment of ignition.)
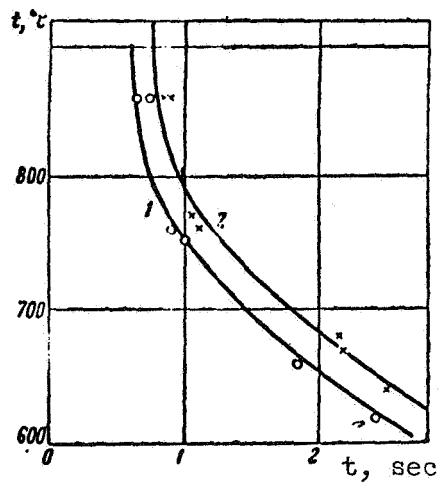1. mazut emulsion, 2. mazut

Figure 9. Influence of the temperature of the medium on the heating period of mazut emulsion and pure mazut particles of one and the same diameter (1, 2 mm), 1. mazut emulsion, 2. mazut

the liquid phase rises continuously and considerably in the course of the combustion of their vapors, whereas, during the combustion of the vapors of emulsified gaseous benzine, the temperature of the liquid phase rises also, but very slightly and monotonically. Thus, at the instant of complete evaporation of the liquid phase of the droplet of gaseous benzine, which in this case coincided with the end of the combustion of the vapors of the emulsion of gaseous benzine, the temperature reached 64°C.

The relative constancy of the temperature of the liquid phase during the combustion of a benzene droplet is also indicated by I. I. Paleyev and F.A. Agafonova, as stated in Ref. 3. D. I. Polishchuk (Ref. 2) has observed that the temperature of the liquid phase during the evaporation of benzene, xylene and benzine rises by 2-3°C. In our experiments, the temperature inside the kerosene emulsion droplet reached 144°C at the moment of disappearance of the liquid phase, whereas the temperature of pure kerosene was 190°C. A still higher temperature reaching 480°-490°C, was noted during the combustion of heavy fuel (mazut).

Under the conditions of our experiments, which were typical for a diffusion regime, the combustion of the vapors and, above all, of light fuel (gaseous benzine) lasted for a fairly long period of time.

The oscillograms showed that the combustion time of the fuel vapors amounted to 80 percent for light fuel(gaseous benzine) and 55-60 percent for heavy and middle fuels of the total time from the moment of their insertion (but not including the burning time of the carbonaceous residue).

Still more remarkable data were obtained by measuring the temperature in the range of the combustion of the fuel vapors. The thermocouple was placed at a distance of 2 mm from the surface of the droplet. The temperature in the region of combustion of the vapors was measured by a differential thermocouple and recorded on film with the aid of a loop oscillograph. The second hot junction of the differential thermocouple was placed at the source of the temperature, equal to the temperature of the medium. The behavior of the droplet was recorded on film at the same time.

Observations were conducted during combustion of mazut and mazut emulsion droplets in a constant air medium at a temperature of 740°-860°C. Typical oscillograms and motion picture films with indication of the characteristic points of these thermographic measurements are shown in Figures 10 and 11.
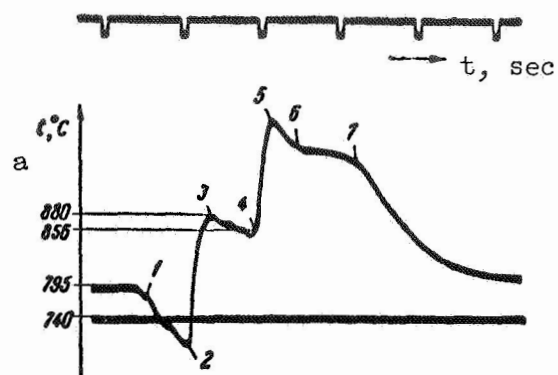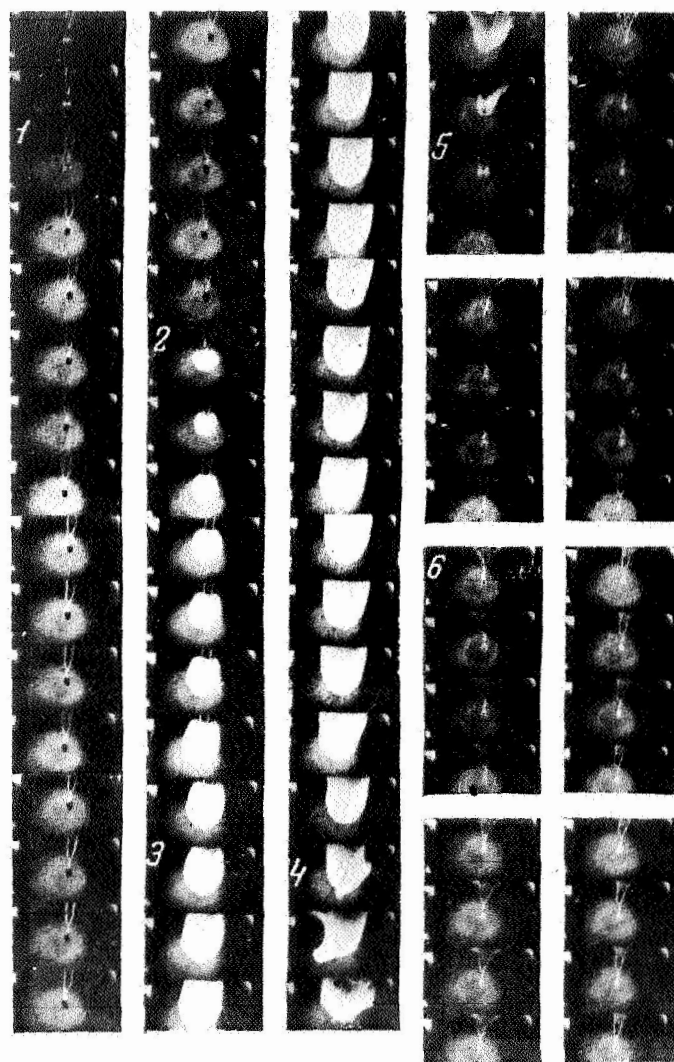
Figure 10a and b (caption on following page)

Figure 10. Typical oscillogram (a) of a thermographic record-
ing of the temperature in the range of the combustion of the
hydrocarbon vapors of a pure mazut particle, and motion pic-
ture film (b) of the heating, ignition and combustion process
of a mazut particle at a temperature of the medium of 795°C.
The figures indicate the characteristic points denoting the
various stages of the process. The corresponding moments on
the film (b) are denoted by the same figures: 1. introduction
of the particle into the heated medium, 2. ignition of the
hydrocarbon fumes, 3 and 4. period of thermal decomposition
of the hydrocarbons in the vapor phase, 5. termination of the
combustion of hydrocarbon vapors, 6 and 7. burning out of
solid carbon

A certain local temperature drop (see Figure 10, point 2) follow-
ing the introduction of the droplet into the reaction zone during the
heating process, prior to the moment of ignition of the fuel vapors of
the fuel, is explained by:

1. The heat expended in warming the cold air which entered to-
gether with the droplet (see point 1).

2. The heat absorbed by the droplet for its heating and its par-
tial evaporation prior to the ignition of the fumes (see point 2).

A sharp rise in temperature (between points 2 and 3) corresponds
to the ignition and combustion of the fuel vapor; as shown by the film,
it lasts until the moment observed at point 5.

However, in the section between points 3 and 4 the oscillograph
registered during the combustion process of the fuel vapors a tempera-
ture decrease of 18°-20°C, which, although quantitatively insignificant,
lasts a fairly long time.

This strange but characteristic phenomenon can only be explained by
the fact that another process involving heat absorption takes place si-
multaneously with the combustion of the fuel vapors over a definite
temperature range (850°-890°). Such an endothermic process causing the
temperature to remain low seems to be the thermal dissociation or
recombination of molecules of high-boiling hydrocarbons in the vapor
phase. The existence of such a reaction has been pointed out by V. H.
Kondrat'yev (Ref. 4), by V. Ya. Shtern (Ref. 5) and Ya. M. Paushkin
(Ref. 6).

Light hydrocarbons and radicals which differ from carbon by a
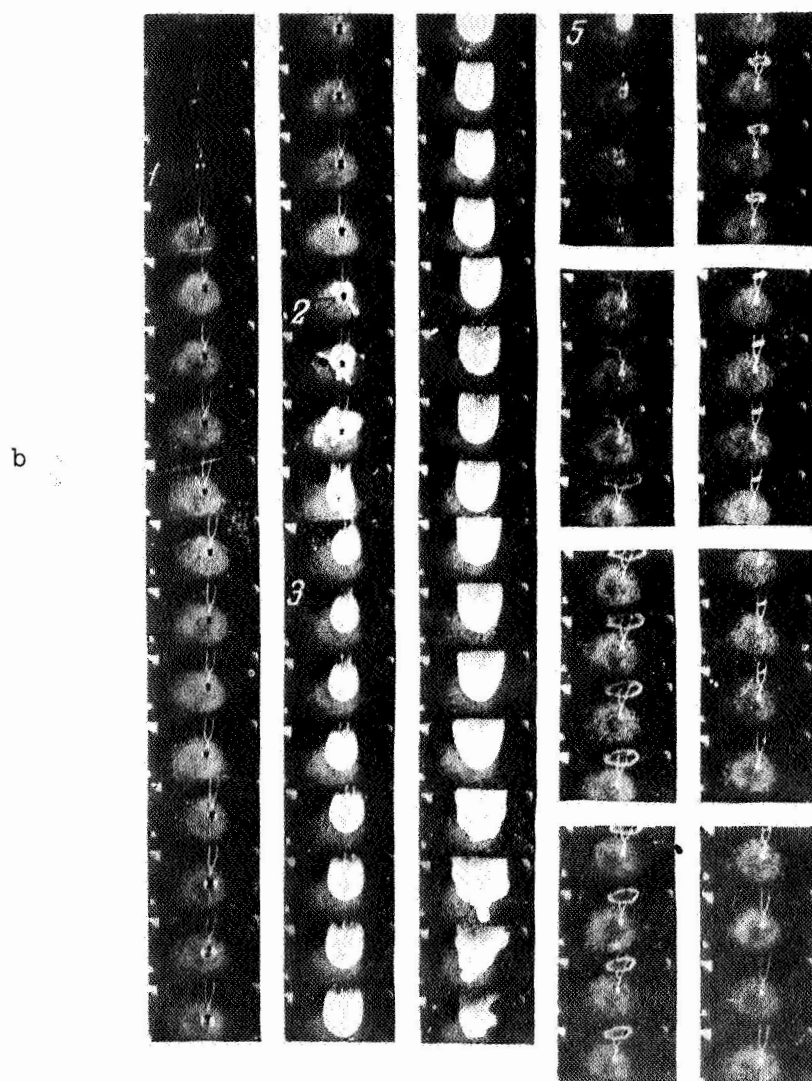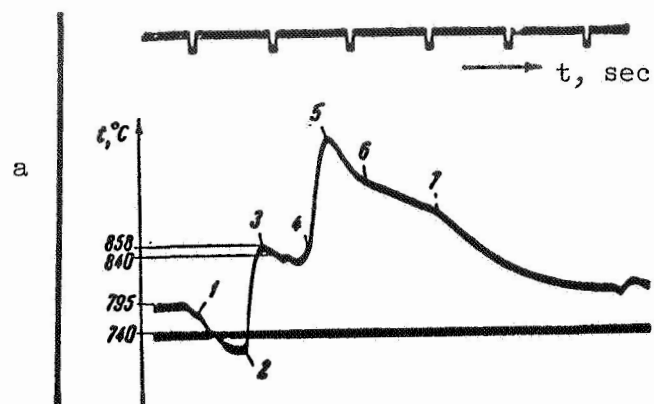higher reactivity, burn faster, intercepting the oxygen entering the

Figure 11a and b (caption on following page)

Figure 11. Typical oscillogram (a) of a thermographic record-
ing of the temperature within the zone of the combustion of
hydrocarbon vapors of a mazut emulsion particle, and motion
picture film (b) of the heating, ignition and combustion of a
particle of a 30 percent water-mazut mixture at a temperature
of the medium of 725°C. (designations of the characteristic
points same as in Figure 10.)

reaction zone; consequently, free carbon and highly condensed aromatic
compounds burn up last, after the combustion of the light and middle hy-
drocarbons.

The combination of motion picture films and oscillograms made it
possible to clarify the sequence and duration of the combustion stages
of heavy fuel: the heating, evaporation and combustion of the vapors,
with thermal dissociation and the burning off of the solid sooty resi-
due under diffusion conditions. The stages of combustion of carbon
are shown at points 5, 6 and 7 on the film and oscillogram. During the
combustion of the droplet on the quartz support, the sooty residues were
concentrated somewhat above the button of the differential thermocouple
(Figures 10 and 11) which is visible in the last frames of the film and
partly on the quartz support. During the combustion of the droplet on
the ring-shaped thermocouple, the sooty residues remained on the ring of
the thermocouple itself. The very same picture and mechanism were also
observed during the combustion of droplets of a mazut emulsion.

(W^p = 20-30 percent, see Figure 11), where both the individual stages
and the combustion process of the droplet of emulsified fuel as a whole
took place more rapidly. Moreover, during the combustion of the emul-
sion at the characteristic points (points 3, 4 and 5) the temperature
was found to be somewhat higher (by 20-22°) than it was at the same
points for the combustion of mazut.

Analogous phemonena were also noted in the combustion of kerosene
droplets; here, however, the period of dissociation of the hydrocarbons
(points 3 and 4) was of lesser duration and the amount of the soot pro-
duced was considerably smaller.

The influence of the temperature of the medium on the combustion
process of heavy fuel droplets is of special interest. A temperature
oscillogram and a film of the combustion of mazut emulsion (d = 1.1 mm,

W^p = 30 percent) with an air temperature inside the camera of 890°C, is
given in Figure 12. It is easy to see that the combustion process in a
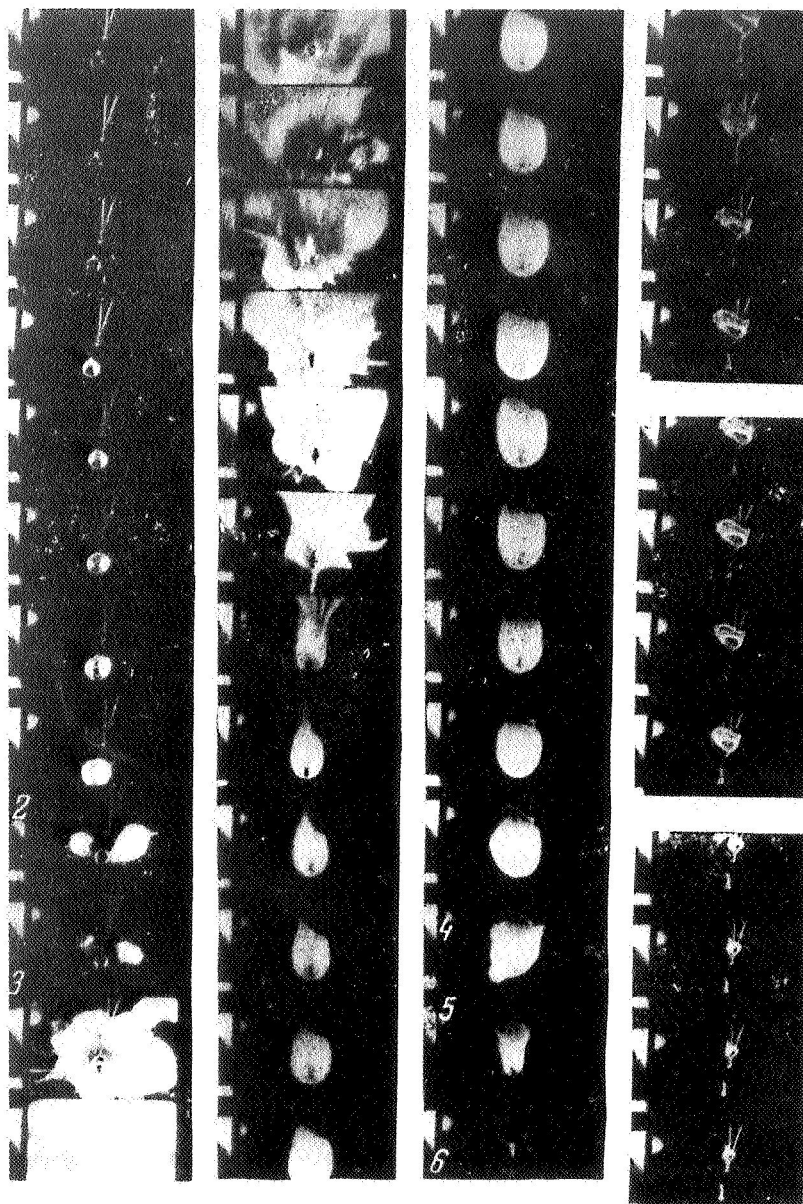higher temperature medium occurs more vigorously and sooner.
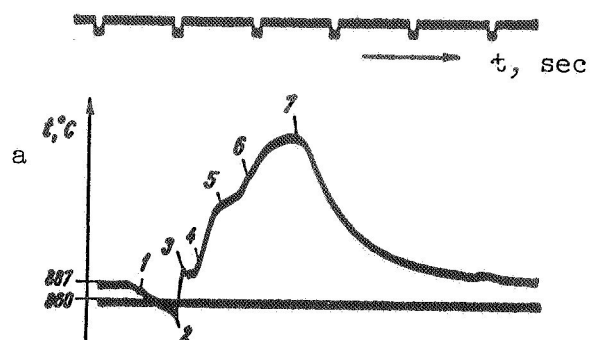
Figure 12a and b (caption on following page)

Figure 12. Typical oscillogram (a) of a thermographic record-
ing of the temperature within the zone of the combustion of
hydrocarbon fumes of a particle of a 30 percent water-mazut
emulsion at a higher temperature, and motion picture film (b)
of the ignition and combustion process of a particle of a 30
percent water-mazut emulsion at a temperature of 887°C.
(Designation of the characteristic points same as in Figure 10)

Although the oscillogram of the temperature changes during the com-
bustion of the emulsion droplet at t_B = 890°C remained the same as at

t_B = 710°C, it is nonetheless remarkable that the interval between

points 3 and 4, which indicates the existence of an endothermic reaction,
is somewhat shortened. The period of the burning off of carbon (soot)
was also shortened. It must be assumed that the increase of the temper-
ature of the medium and the effect of the radiation of the surfaces dur-
ing the combustion of the liquid (particularly heavy) fuels exerts a
substantial influence on all stages of the process. The final stage,
i.e., the burning of the sooty residue, is of course particularly signi-
ficant in the combustion of liquid and especially heavy fuels. The time
of burning of the carbonaceous residue during the combustion of both
mazut and mazut emulsion droplets were established by measuring the tem-
perature and filming (Table 2).

The data in Table 2 show that the burning of the sooty residue re-
quires 30-40 percent of the total time of combustion of the droplet.
Consequently, this is a factor which must not be disregarded, even in
those cases where the temperatures are higher, the mixing of fuel vapors
and atmospheric oxygen is more homogeneous, and the regime is turbulent
in character.

In addition to the study of the behavior of single droplets, the
experiments involved observations of the combustion of groups of drop-
lets of mazut, its emulsion, and kerosene. Five droplets were intro-
duced simultaneously on a quartz support, the temperature was measured
in the combustion zone of the vapors, and motion pictures were taken
at the same time (200-300 frames per sec).

Observations of group combustion of the droplets established that
it has much in common with the combustion of a single droplet. After
introduction of the droplets into the heated medium, their ignition is
retarded for some time, owing to the warming of the droplets, the for-
mation of fuel fumes, and, under actual conditions, to the warming of
the air up to the required temperature.

Table 2

Fuel	Water content percent	Diameter of drop-let mm	Tempera-ture of medium °C	Total time of combus-tion of droplet sec	Combustion time of car-bon residue sec	Proportion of combus-tion time of carbon residue percent
Mazut M-60....	0	1.1	740	3.3	1.4	42
Emulsion of mazut M-60....	30	1.1	740	2.78	1.1	39
Emulsion of mazut M-60....	30	1.1	890	1.82	0.49	27

A flame center forms, the appearance of which is followed by a rapid ignition of the entire mass of fuel vapor, and the whole group of drop-lets is engulfed by flames. This circumstance refutes the incorrect treatment of the combustion of a mass of droplets of liquid fuel as a sum of processes of diffusional combustion of single droplets, each of which is wrapped in a separate stationary envelope of its vapors (as stated in Ref. 7).

Thus, the spreading of the flames to the fuel vapors of the group of droplets of, for example, kerosene, mazut and mazut emulsion, pro-ceeds from the common center of ignition and assumes the character of a rapid relay (see Ref. 8). The combustion of the vapors lasts a consid-erable period of time, during which endothermic reactions characteristic of the cracking of hydrocarbons with separation of sooty residues also take place.

The combustion of the fuel droplets does not occur simultaneously. Fine droplets burn first. The sooty residues burn last, after the fuel vapors have burnt out. With the group burning, the sooty residues split into parts and burn out not only in the case of heavy fuels (mazut and water-mazut emulsion), but also in the case of kerosene. Actually, the amount of these residues is in this case considerably smaller than in the combustion of heavy fuels and therefore they burn out faster and remain on the same quartz supports, on which the droplets were inserted into the reaction zone.

The described phenomena of the formation of sooty residues, which have been observed in our experiments during the combustion of single droplets and of groups, are by no means a coincidence; they also take place in internal combustion engines, boilers, furnaces and other thermal units. In motors this phenomenon is called scale formation.

The characteristic difference between the combustion of emulsified and anhydrous mazut, observed in single droplets, remains valid in groups of droplets. The whole combustion process of a group of emulsified droplets consists of identical stages: heating and evaporation, explosions, combustion of vapors, including cracking of hydrocarbons, and the final stage--the burning of the sooty residue. The combustion of the group of emulsion droplets takes place as vigorously as that of the anhydrous mazut, only more rapidly.

Thus, our study on the combustion of droplets, undertaken with the single aim of establishing the difference between the combustion of natural anhydrous and water-containing emulsified fuel, answered not only the question asked, but also clarified several other general problems concerning the combustion of liquid fuel. Simultaneous application of filming and temperature measurement of the liquid phase of burning droplets within the range of the combustion of the fumes made it possible to establish definitely, that combustion of liquid fuel must not be deemed as simple as is done by some researchers; that the whole combustion process of atomized fuel in flow must not be reduced to the pattern of diffusional combustion of the single droplet or the process reduced to only one stage, that of evaporation, or only to the combustion of a separate droplet. The combustion of liquid fuel is actually a very complex process consisting of the stages described above.

These stages, although taking place in definite sequence, overlap each other in time and space. Hence, the duration of the combustion process, as a whole, may also vary, depending upon the conditions of the given apparatus and, of course, on the type of the fuel itself.

The results of the comparison of the combustion of anhydrous and water emulsified liquid fuels have proved the following:

1. Emulsified liquid fuels burn faster than anhydrous ones.

2. Water in emulsified fuels does not impair, but improves the combustion process, owing to the additional simultaneous breaking of the droplets to the increase in the evaporation surface of the droplets, and to a better mixing of the burning substance with air.

3. The reduction of the combustion time of emulsified fuels has a favorable influence on the burning of the sooty residue, thus improving the completeness of the fuel combustion and reducing the deposition of soot (scale) on the working surfaces.

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